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GEOLOGY AND HYDROLOGIC DATA FOR THE
PHASE II GROUND WATER STUDY FOR
THE HOOKER CHEMICAL PLANT
TACOMA, WASHINGTON

AUGUST 17, 1980

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INTRODUCTION

This report presents a summary of the results of the Phase II groundwater field investigation conducted by Hart-Crowser & Associates, Inc. at the Hooker Chemicals and Plastics Corp. plant at Tacoma, Washington. The purpose of the study was to obtain baseline data pertinent to the geology, hydrology and geochemical conditions in the vicinity of the plant property. The study was made at the request of Mr. Carl Virgil, Plant Works Manager. Mark Utting of Hart-Crowser & Associates, Inc. was in charge of all field activities associated with the work and was assisted by Mike Longinotti and Bill Bergmann. Overall supervision and guidance of the project was provided by William H. Walker of Walker Wells, Inc.

The initial section of the report presents some of the safety and liability precautions followed during the field work. The main body of the report discusses the methods and procedures of data collection, including baseline geologic and hydrologic data, together with chemical data of the saturated and unsaturated zones beneath plant property.

Safety and Liability Precautions

Because of the potential dangers and liabilities which are inherent in working with heavy equipment and in handling materials which contain contaminants which may be dangerous

in large doses or with long-term exposure, many safety precautions were undertaken by all personnel working on this project. Special equipment was used, special attitudes were developed and special procedures were followed. The safety precautions included;

- 1) A safety seminar presented by Don Oderkirk of Hooker Chemical,
- 2) Blood samples drawn before and after completion of the field work,
- 3) Protective safety equipment (chemical-proof clothing, respirators, safety goggles, boots, etc.) used whenever possible,
- 4) Direction by Hart-Crowser personnel to drilling crews to follow safety procedures,
- 5) Removal to Hooker property of all off-site cuttings and water produced during drilling,
- 6) Steam-cleaning of the drill rig and all associated equipment, including replacement of the drilling cable.

Methods and Procedures of Data Collection

During the course of the study, baseline data pertinent to the geology, hydrology and chemistry of the saturated and unsaturated zones beneath the project site were obtained. The subsurface stratigraphy was explored with deep soil borings. Hydrologic data was collected with wells installed in the soil borings. The chemistry was obtained from samples drawn from the finished wells and from shallow explorations in the unsaturated zone.

Drilling and Sampling

Subsurface conditions were originally to be sampled with a hollow-stem auger. Subterranean Drilling Co. of Gig Harbor, Washington

was contacted to sample soil and water and to install PVC observation/sampling wells. They commenced drilling at Site 1 on February 11, 1980. Because the silty fine sands repeatedly heaved up inside the casing during drilling, producing nonrepresentative soil samples and questionable samples of water, this drilling technique was abandoned.

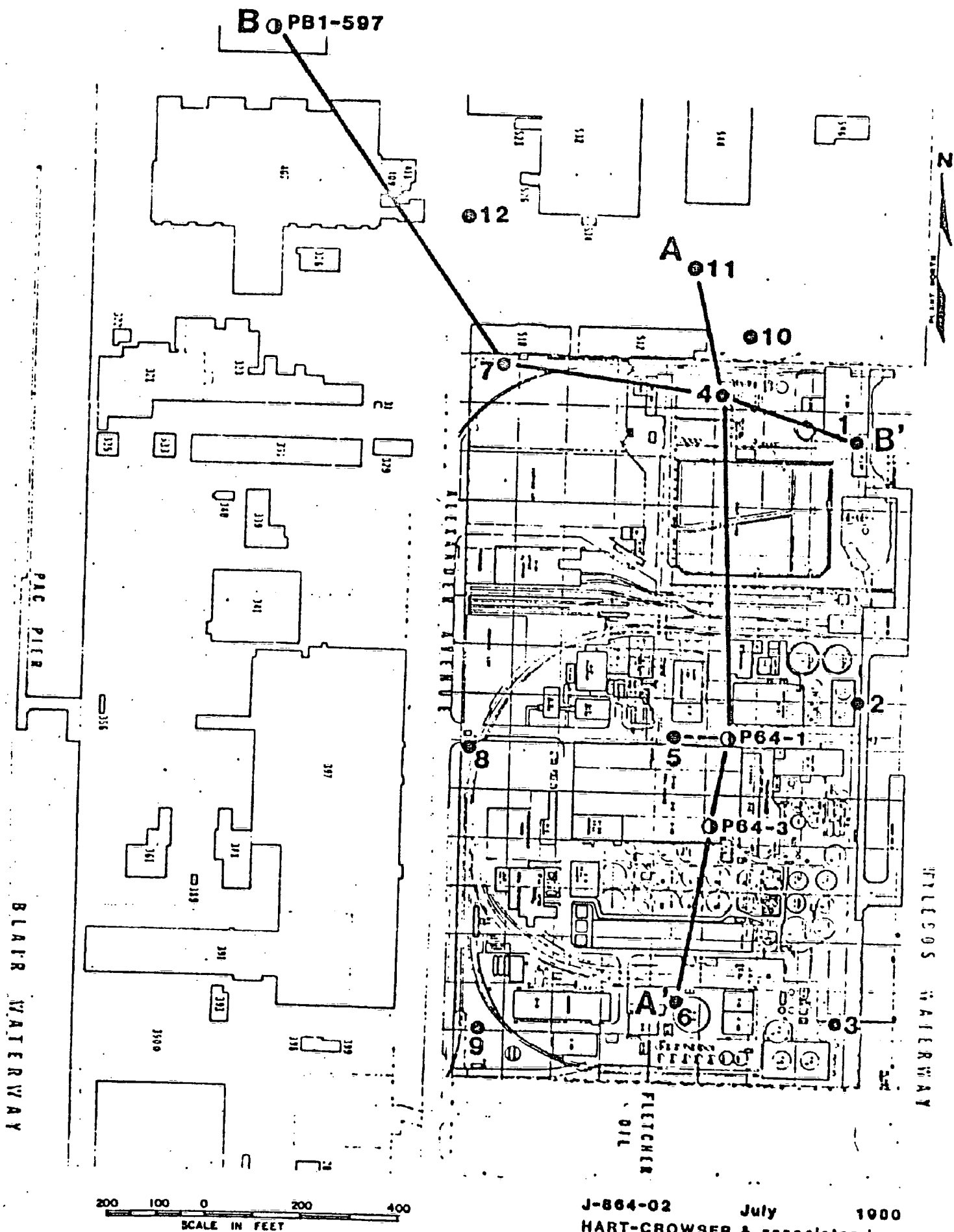
Bill Dodge and Bob Watson of Story-Dodge Drilling of Graham, Washington commenced cable-tool operations on February 20, 1980. They were joined by Ed Story and Bob Carper with a second rig on the 5th of May and continued until June 6, 1980 when the drilling program was completed.

The locations of the borings are shown in Figure 1. Each boring, (and subsequent well, described in the next section) is numbered according to site number and depth. For example; Well 4-115 is at Site 4, and has the bottom of the screen at 115 feet.

The cable-tool drilling rigs were used to obtain soil samples required to define subsurface stratigraphy and water samples used in conjunction with qualitative chemical analyses to help design observation/sampling wells. Water samples, usually consisting of a slurry of soil and water, were obtained from each 5-foot interval directly from the bailer. Care was taken to clean the bailer before each sample was drawn.

Qualitative chemical analyses of water and soil samples obtained during drilling assisted in design of the finished wells. These chemical analyses were only of limited value because of the "carry down" phenomenon and should not be viewed as indicating true concentration with depth.

WELL AND GEOLOGIC CROSS SECTION LOCATIONS

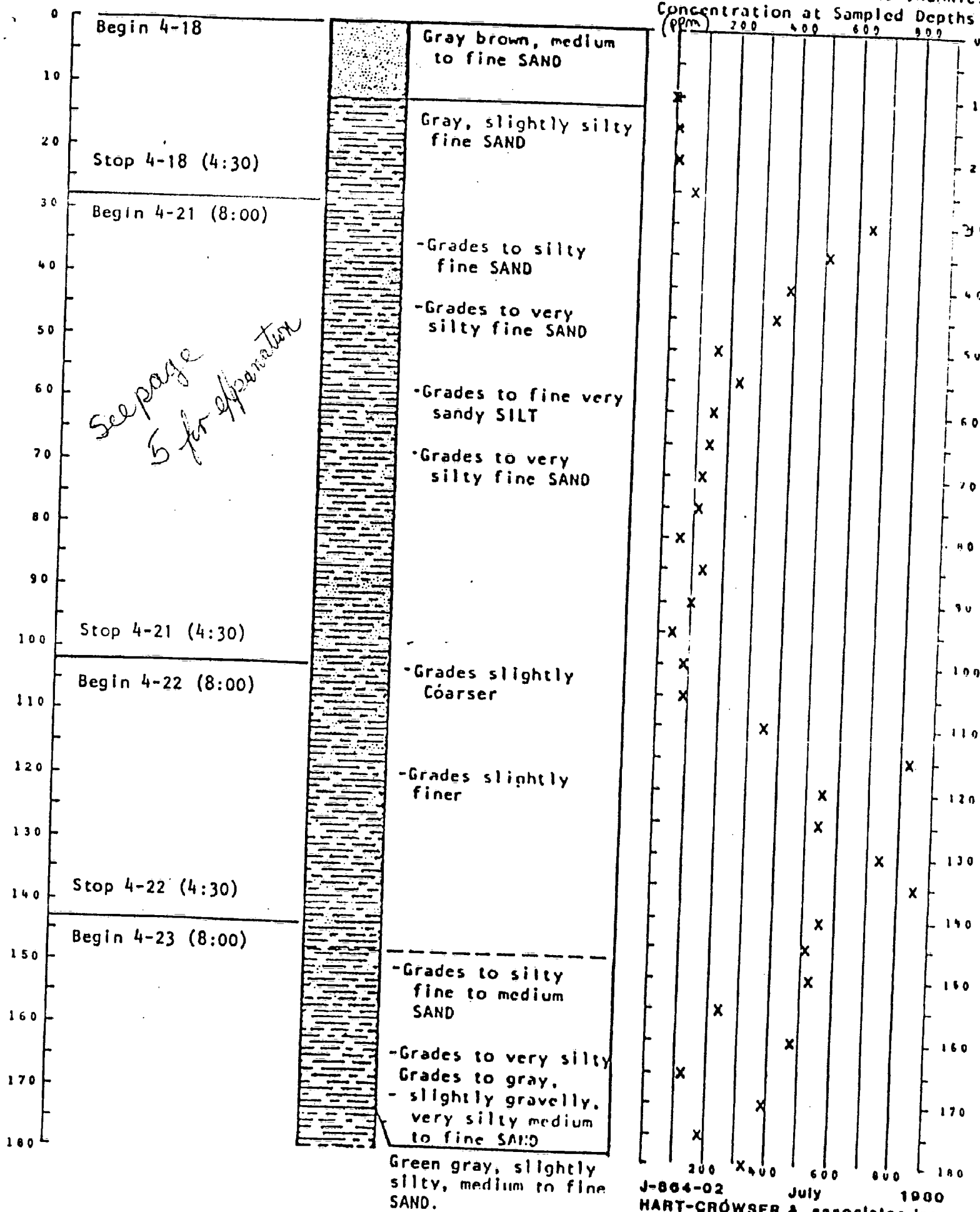


Carry Down as Delineated by Drilling Schedule and Chemical Analysis Well 1-175

DRILLING SCHEDULE

GEOLOGIC LOG

QUALITATIVE CHLORINATED ORGANICS
Concentration at Sampled Depths
(ppm) 200 400 600 800 1000

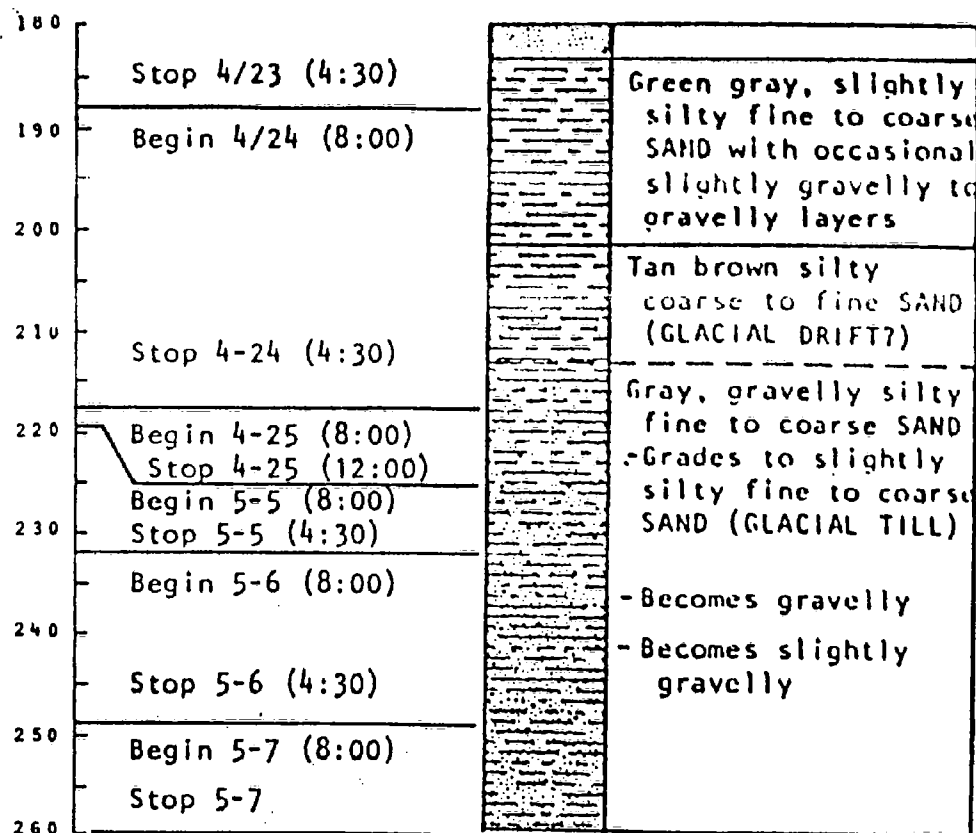


Carry Down as Delineated by Drilling Schedule and Chemical Analysis Well 1-175 (Cont.)

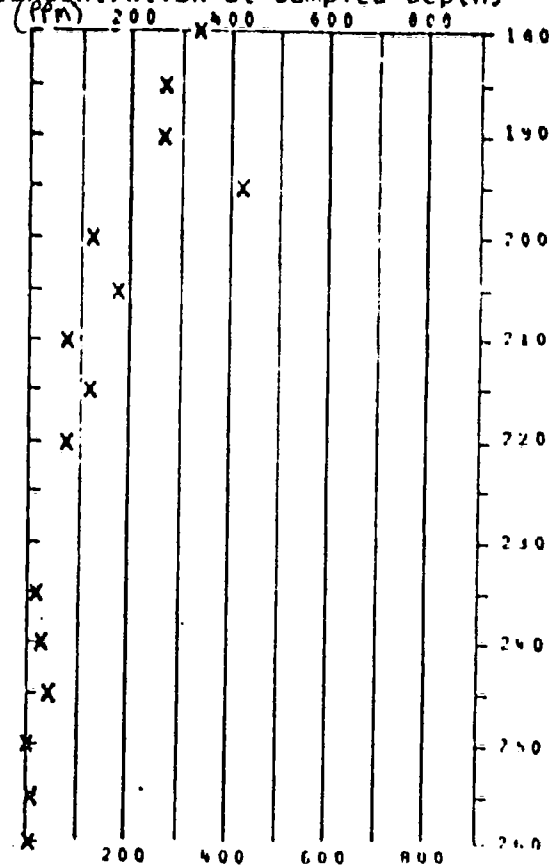
DRILLING SCHEDULE

GEOLOGIC LOG

QUALITATIVE CHLORINATED ORGANICS Concentration at Sampled Depths



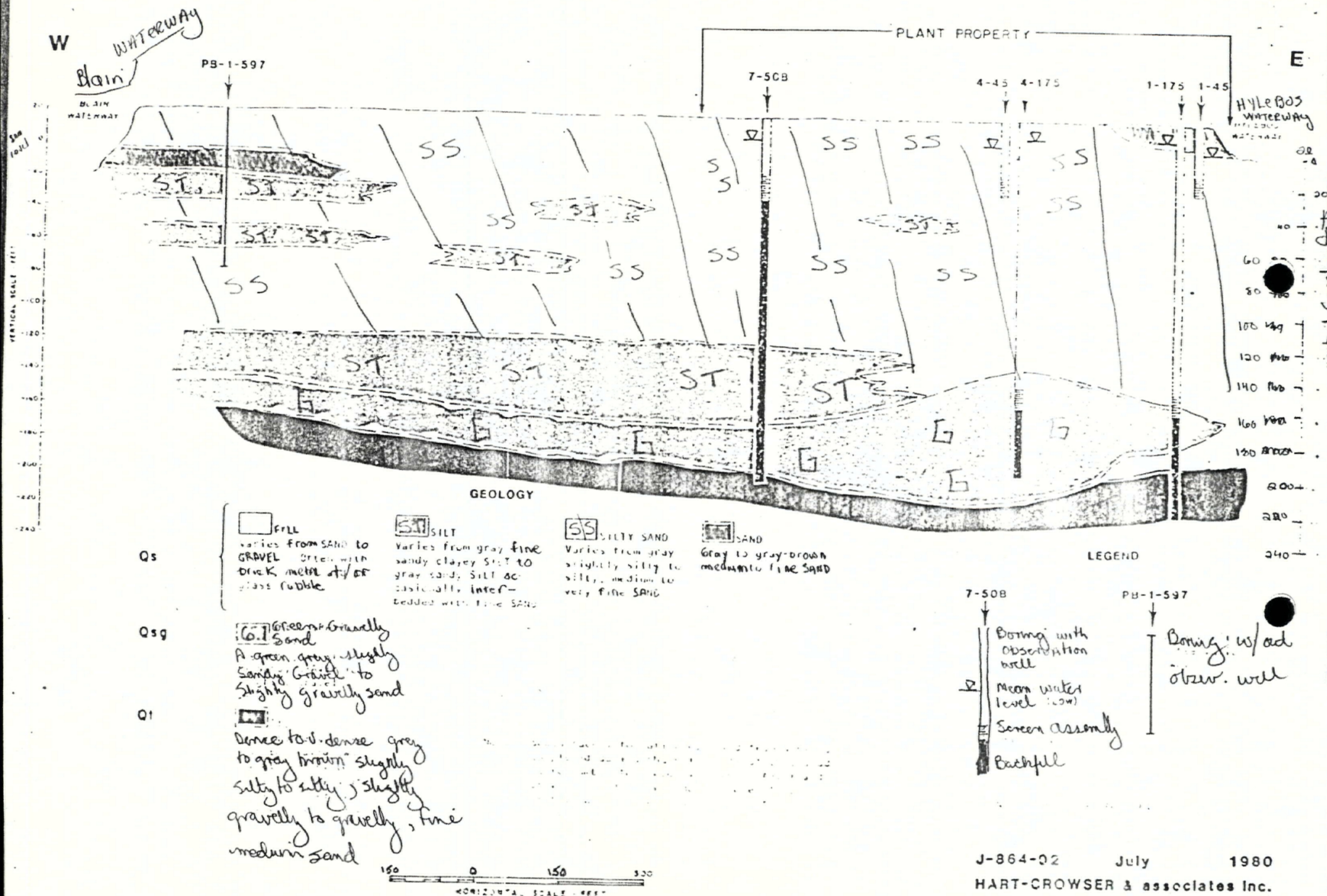
Bottom of boring
completed 5/12/80



N



GEOLOGIC CROSS SECTION W - E



Carry-down is the downward movement of water outside the well casing through the annular space provided by the driveshoe as it is driven downward. We believe that many of the values indicated for chemical concentration during drilling may be too high because of carry-down. In examining the increase in chemical concentration at points below what appeared to be the main zone of contamination, we noted that many of the increases in concentration with depth coincided with overnight shutdown. It appears that while the drill rig was shutdown for the night, downward hydraulic gradients and/or the density contrast between water and chlorinated organics (approximately 1-1/2 times more dense than water) pushed the organics downward from higher zones to where they were sampled the next day. Thus, many of the sharp increases in contamination at depths below the main zone of contamination may be products of carry-down and not of true groundwater chemistry; therefore, only the final samples obtained from the purged wells should be considered representative of chlorinated organic concentrations at depth.

Figure 2 shows the relationship of overnight shutdown and concentration of chlorinated organics for well 1-175. It can be seen that the concentration of organics often increased sharply after shutdown time allowed carrydown to occur.

Geology

The results of the subsurface borings are shown in the well logs included in Appendix A, Figures A-1 through A-12. Based on the work of Walters and Kimmel (1968) and on a report by Hart-Crowser & Associates (1979), three major hydrogeological units have been defined as seen in the geologic cross sections, Figures 3 and 4 (located on Figure 1). At a depth of 200 feet or more lies a glacial till which typically is a dense to very dense, gray to gray-brown, non-silty to slightly silty, gravelly fine to medium SAND (Qt).

geology
description

The till varies somewhat in particle-size analyses. Two typical grain-size analyses are shown in Appendix A, Figure A-13. The till, being dense to very dense and low in permeability, forms the bottom of the local hydrogeologic system beneath the plant property.

Overlying the till is a discontinuous, medium dense, green, slightly silty SAND to a sandy GRAVEL (Qsg). As seen in the well logs, the green SAND to GRAVEL is found in some locations but not in others and varies in grain size from a slightly silty SAND to a sandy GRAVEL as is shown in Appendix A, Figure A-14. It appears that the variability in presence and grain size is either a function of the original mode of deposition (fluvial), erosion subsequent to deposition or both. Hydrologic data presented in a following section indicates this unit is hydrologically connected to Commencement Bay.

The surficial unit beneath the project site consists of fluvial deltaic deposits comprising silty sand strata up to 200 feet thick. The upper silty sand unit varies in some places from a clean, fine to medium SAND near the surface to a silty, fine SAND containing layers of sandy SILT at depths below 50 feet. Well-defined beds were not observed to be continuous between the wells. Four typical grain sizes are shown in Appendix A, Figures A-15 and A-16.

Grain size analyses for samples taken at 5-foot intervals in the upper silty sand of two borings (Wells 1-175 and 4-175) helped in the description of the units presented in the well logs and in field identification of samples from other borings. The similarity between particle size analyses for all the silty sand unit samples

indicate that, in spite of local variations, the unit probably acts as one hydrogeologic unit which is macroscopically homogeneous.

Well Installation

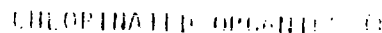
Twelve wells were installed to obtain hydrologic data on direction and gradients of groundwater flow. The wells were installed in the soil borings at depths and locations determined by geology, general hydrogeology and qualitative chemistry data obtained during drilling of the deep borings.

? Four deep wells (160 to 183 feet) were installed to assess water levels at depth with respect to those in shallow zones (thereby indicating hydraulic gradients) and so that samples could be drawn to demonstrate whether contaminants had migrated to depth. The shallow wells (45 to 50 feet) were located within 15 feet of the deep wells where comparative water levels could be measured and at a depth where the zone of highest chlorinated organic concentration could be sampled. A diagram of a typical well is included as part of Figure A-1 in Appendix A. *Zone of highest chlorinated organic concentration. 45-50' deep.*

Water Level Measurement

Five Stevens Type F recorders were used to collect well level data for the period of mid May to late June. Between June 26th and July 2nd, wells 1-45, 4-45, 7-50B, 11-45 and 12-45 were measured to obtain high and low water levels and time lags as a function of distance inland. Lag times between the water level of each well and the level of the Hylebos were calculated or extrapolated from the recorder data.

Z



☐ 0.9 ppm to 11.7 ppm
☐ 42.0 ppm to 116.2 ppm
☐ 91.4 ppm to 88/4.9

		AREA (11.2)	VOLUME (14.3)
AREA 1		29088	86.19
		16127	30.21
AREA 2		36567	109.25
		3690	10.03
		5046	15.94
AREA 3		7676	23.15
		4742	14.07
TOTAL		21470	65.58
		13887	42.19
		9591	29.44

each ploygon was measured planimetrically, then the volume of the soil affected and the total stored weight of chlorinated organics were calculated (based upon a 8-foot thick unsaturated zone). The total volumes should only be considered approximate as the number of sampling stations was small. The test pit and hand-auger sampling locations along with the Thiessen weighted polygons are shown in Figure 8.

Chemical Analytical Procedures

Samples from each location were collected in glass jars with Teflon-lined lids and taken promptly to the laboratory for analysis. In cases where immediate analysis was not possible, soil samples were frozen and water samples were chilled.

Because of different requirements for each type of sample, different degrees of precision were used in the analyses. The water and soil samples obtained during drilling were analyzed in a fast, non-precise manner because only rapid, qualitative results were required. Similar precision was required for samples obtained during purging of the finished wells. Exact analyses were required for the final well samples only. Because great care was taken in obtaining these samples, an equal amount of care was used in their analyses.

The same analytical procedure was used for all samples, with only the degree of precision varying as a function of the accuracy desired. The following procedure, excerpted from a report by Clair Candler of Hooker Chemicals and Plastics Corp. dated July 2, 1980, was used:

"Each water sample was extracted with o-dichlorobenzene. Each core, test pit and hand auger sample was extracted with a combination of isopropanol and o-dichlorobenzene. The isopropanol was used to obtain better extraction between the o-dichlorobenzene and sample. The isopropanol

was removed by two consecutive water washes to obtain the o-dichlorobenzene extract. The extraction efficiencies were as follows: (determined by extracting known amounts by the above method)

	Chlorohydrocarbon	Percent
(dichloromethane)	Methylene Chloride CH_2Cl_2	65
Trichloroethane	Chloroform CHCl_3	116
(tetrachloroethane)	Carbontetrachloride CCl_4	86
	Trichlorethylene C_2HCl_3	78
	Perchloroethylene	77

The gas chromatographic column used was a 6' x 1/8" nickel column packed with 5% QF-1 and 3% DC 200 on 80-100 chromosorb W/HP. The column was run isothermally at 50°C for seven minutes to elute all the low-boiling chlorinated organics, then temperature programmed at 30°C/minute to 180°C and maintained for four minutes to elute out the solvent peak prior to the next run. Sample size was 0.5 µl. The gas chromatograph was a HP 5830 converted to a 5840 using a FID detector.

Standards were prepared by injecting a known amount of each of the five (methylene chloride, chloroform, carbon tetrachloride, trichlorethylene and perchlorethylene) into a loosely capped 25-ml Wheaton bottle that contained some o-dichlorobenzene. The bottle and contents were weighed before and after each injection of each of the low boilers to obtain the weight of each low boiler. The actual concentration of each low boiler was obtained and calculated from the weight difference between the filled and empty bottle. Standard concentrations from 10 to 700 ppm were prepared in this manner. Initially three to five injections were run from a single standard to obtain a reproducible value for each of the five compounds. An injection of a standard was done at least once a week to verify relative retention times and the value of each of the compounds sought. The factor for each standard varied little."

Ground Water Chemical Analyses

Chemical analyses from the finished wells are presented in Table 2. These samples (excluding 4-83 and 4-115) were obtained with a peristaltic pump and not exposed to aeration. Thus, we believe that these samples are truly representative. Samples from 4-83 and 4-115 are of questionable value as previously discussed under Chemical Sampling Procedures.

TABLE 2
TOTAL CONCENTRATIONS OF CHLORINATED ORGANICS, SODIUM HYDROXIDE
AND SALT IN FINAL WELL SAMPLES

Well	CHCl ₂ (ppm) ² <i>Methylene chloride</i>	CHCl ₃ (ppm) ³ <i>Chloroform</i>	CCl ₄ (ppm) ⁴ <i>Carbon Tet.</i>	Fe C ₂ HCl ₃ (ppm) ³ <i>Trichloro</i>	C ₂ Cl ₄ (ppm) ⁴ <i>Percylo</i>	Other Cl-Organics (ppm)	Total Cl-Organics (ppm)	NaOH (mg/l)	NaCl (mg/l)
1-45	1.0	75	0	6.9	2.0	3.0	87	0	99,600
1-175	0	0	0	0	0	0	0	0	29,300
4-45	4.0	466	0	160	42	0	672	0	43,200
4-83?	3.0	277	0	95	25	0	400	0	28,800
4-115?	0	5	0	2.0	1.0	0	8	0	31,700
4-175	0	0	0	0	0	0	0	0	8,000
7-50B	12	224	0	30	0	0	266	0	63,800
10-45	8	68	0	315	19	0	410	0	10,600
11-45	0	3.0	0	110	1.0	0	5.0	0	11,000
11-183	0	0	0	0	0	0	0	0	12,700
12-45	0	0	0	0	0	0	0	0	15,200
12-160	0	0	0	0	0	0	0	0	13,700

Total Organics
2 city - up to
10,000 ug/l

A graphical display of the analyses for the water pumped during the presampling period is shown in Figure 9. Concentration is graphed vs. time pumping. Wells 1-175, 4-175, 12-45 and 12-175 are not plotted because the concentration of chlorinated organics was 0 at all times.

It can be seen that all wells except 4-83 reached equilibrium after being pumped for 9 to 14 days. It appears that non-representative water introduced during drilling was removed during pumping and an equilibrium was reached.

Concentrations in Well 10-45 remained high and then dropped radically to near zero. Based on the final well analysis, we do not believe that this decrease was real. Thus, the cause of this drop is not understood.

Water from Well 4-83 did not reach equilibrium and continued to increase in chlorinated organic concentration. We believe that pumping produced an outwardly expanding cone of influence which moved contaminants to the well from other horizons as pumping progressed.

A final sampling of the 45 to 50 feet deep wells was conducted on August 12 and 13, 1980. The results are listed in Table C-1 in Appendix C. Analyses for NaOH, pH, Na_2CO_3 , chlorinated organics and NaCl were performed. Wells 1-49, 4-47.5, and 10-45 displayed organic concentrations above approximately 170 ng/L. Wells 7-50A and 11-45 displayed concentrations below approximately 60 mg/l.

Wells 2-79.5 and 5-50 displayed NaOH concentrations of 8,000 and 3,700 mg/l respectively. The pH of these samples was also higher than samples showing zero NaOH concentrations.

TABLE 3

CHLORINATED ORGANICS STORED IN UNSATURATED ZONE 1

	TEST PIT #	AREA POLYGON (Sq. ft.)	VOLUME (Cubic ft.)	CHLORINATED ORGANICS (PPM)	TOTAL CHLORINATED ORGANICS 2 (LBS)
AREA 1	TP 14	4788	38304	115.2	503.0
	15	6282	50256	0.9	5.2
	16-I	3528	28224	1.1	3.5
	16-0	2295	18360	1.2	2.5
	20	2187	17496	8.6	17.2
	21	5409	43272	113.9	561.9
	28	585	4680	2.6	1.4
	29	4437	35496	3.3	13.4
	32 ³	2169	17352	6.3	12.5
	SE	7605	60840	5.4	37.5
					TOTAL = 1158.1 lb
	AREA 2	1	2025	16200	65.3
2		1665	13320	42.0	63.8
3		1125	9000	1.0	1.0
4		1260	10080	1.4	1.6
5		1278	10224	1.7	2.0
6		2358	18864	2.0	4.3
7		1395	11160	11.7	14.9
8		1872	14976	2.2	3.8
9		1890	15120	10.2	17.6
10		1557	12456	2.7	3.8
11		2884	22752	2.3	6.0
12		1656	13248	4.0	6.0
13		1872	14976	3374.9	5761.8
17		1971	15768	2.1	3.8
18		6174	49392	2.2	12.4
19		2160	17280	1.6	3.2
30		1062	8496	2549.8	2469.6
31		2115	16920	971.4	1873.7
HA 3		1638	13104	4.6	6.8
HA 4		1971	15768	3.5	6.2
HA 5	1845	14760	4.7	7.9	
HA 6	2259	18072	3.0	6.3	
HA 7	1314	10512	2.8	3.3	
				TOTAL = 10400.4 lbs.	
AREA 3	22	4752	38016	1611.4	6983.5
	26	7434	44604	1.1	5.6

- 1 - Average thickness of unsaturated zone = 8 feet
 2 - Estimated Soil Density = 114 lb/ft³
 3 - SE = Area on southeast side of pond. No test pit dug. Values are averages from other perimeter test pits.

Unsaturated Zone Analyses

The chlorinated organics concentration for each one-foot sample interval of the test pits and hand auger holes are shown in Appendix C, Figures C-1 through C-5. These values are given to two significant figures. The mean concentration, area and volume of soil within the Thiessen polygon for each sample location are listed in Table 3. Based on a density of 114 lbs/ft³ for the soil (from previous soil explorations on the Hooker site), the total volume of soil and the total weight of chlorinated organics represented by each sample location and the combined totals for each of the six areas of suspected chlorinated organic concentrations are also listed in Table 3.

Figure 8 shows the areal extent of contamination by color within the suspect areas based upon the Thiessen polygons. As illustrated in Figure 8, all three areas of suspected organic accumulation appear to be affected: Area 1, the abandoned sediment pond under the construction-storage lot, part of Area 2, the open area plant-east of the old solvents plant and part of Area 3, near the two TCE tanks.

The perimeter of the old settlement pond (Area 1) appears to have low concentrations of organics (green zone) but parts of the area under what used to be the pond still have high concentrations. We estimate the total volume of affected and overlying soil (yellow zone) to be up to 3,000 yd³ containing a total of approximately 1,100 lbs of organics. However, because the number of sampling stations is small and the variability is large, both of these figures could be upper limit estimates.

The plant-eastern half of the open area, located plant-east of the old solvent building (Area 2) appears to have very high organic concentration. We estimate that up to 1,500 yd³ of soil (red zone) and 10,000 lbs. of organics may be involved. The center of Area 2 (yellow zone) is estimated to contain 100 lbs of organics affecting

approximately 1,100 yd³ of soil. The remainder of Area 2 appears to be relatively uncontaminated with an estimated total of about 25 lbs. stored in the soil (green zone).

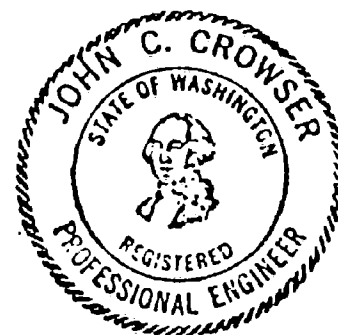
hydrocarbons
The part of Area 3 near the TCE tank appears to be storing a large amount of chlorinated organics (red zone). We cannot at this time accurately quantify the total volumes of affected soil. Digging and boring in this area was difficult because of the scrap steel used as fill material after the settlement pond was removed in the early 1950s. Unfortunately, only two test pits could be finished to depth within the time frame of this project. As can be seen in Table 3, the test pit near the TCE tanks had high organic concentrations, while the test pit to the south was relatively uncontaminated. More test pits near the tanks would be needed to delineate the extent of contaminated soil. We estimate that, as an upper limit, up to 1,400 yd³ of soil may contain up to 7,000 lbs of organics; but in all probability the actual totals may be lower.

HART-CROWSER & ASSOCIATES, INC.

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**Hooker
Chemical
Company**

DATE: December 12, 1980

TO: R. L. Hall
R. D. Luss

FROM: G. M. Rand

COPY TO: T. R. Johnston
D. A. Guthrie

SUBJECT: Evaluation of Concentrations of Chlorinated Organics at the
Tacoma Plant, Washington

The following report was prepared on the above subject. It was reviewed and edited by Dr. P. O. Nees.

Gary M. Rand

G. M. Rand
Associate Corporate Toxicologist

GMR82Qbp
12/12/80

Enclosure

The following discussion is an evaluation of the potential impact of dichloromethane (methylene chloride), chloroform, trichloroethylene and perchloroethylene (tetrachloroethylene) based on concentrations of these organics found in the groundwater at the HCC plant in Tacoma, Washington. A summary of background information from Walker Wells, Inc. and other consultants will first be presented. Then in light of this data known background levels surveyed from raw water and drinking water will be discussed along with the recent water quality criteria issued by U.S. EPA on the 64 priority pollutants (Federal Register, Vol. 45, No. 231, Friday, November 28, 1980).

Background

In the Phase II Report by Walker Wells, Inc. (Groundwater Conditions in the Vicinity of the Tacoma, Washington Plant Phase II - August, 1980) chemical load calculations were made in order to obtain some estimate of the amounts of chlorinated organics which might be leaving the solvents plant area thru the groundwater-flow system. In these calculations total organic concentrations of 497 and 672 ppm were used. These values were the maximum concentrations obtained during Phase II at Well 4-45; the center of the area reported to be the primary source of this material. The values of groundwater outflow used were for assumed maximum outflow periods of 6 and 12 hours. These daily rates were 2100 and 4200 gpd respectively for the solvents plant area. The chemical load calculations showed that from 9-24 lbs. of chlorinated organics may be leaving the solvents plant area each day. These values were further refined in the following report by Walker Wells, Inc. (December, 1980) to a chemical load of 6-12.6 lbs./day of chlorinated organics leaving the solvents plant area. This is explained below.

In the report by Walker Wells, Inc. (Groundwater - Quality and Corrective-Action Concerns at the Tacoma, Washington Plant - December, 1980) they discuss the chlorinated organics in three surficial source areas (1, 2, 3) of the plant. These areas were previously defined by Hart-Crowser and Associates, the consulting group responsible for field

TABLE 1 Groundwater Loading of Chlorinated Organics (lbs.) Within Source Areas 1, 2, 3

<u>Source Area</u>	<u>Pounds of Total Organics Contained Within the Zone of Saturation</u>		
	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>
1	749	1,874	3,437
2	17,407	22,416	28,530
3	803	1,994	3,295

TABLE 2 Outflow Rates of Total Organics

<u>Source Area</u>	<u>Outflow Quantities in lbs./day</u>		
	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>
2	4.84	6.23	7.93
3	1.14	2.83	4.68
TOTAL	6	9	12.60

TABLE 3 Theoretical Concentrations of Total Organics in the Hylebos After Dilution

	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>
Groundwater Outflow of Organics to the Hylebos (lbs./day)	6	9	12.6
Resulting Dilution Effects of Tidal Exchange Water in the Hylebos Waterway on Concentrations of Organics (in ppb)	0.67	1.01	1.42

gathering. Within each area three concentration levels (minimum, average, maximum) were defined as a result of the total organic concentrations found in groundwater samples from 1979-80. Within Area 2 (Wells #4 and #10 - vicinity of abandoned solvents plant) and Area 3 (Well #1 - vicinity of old TCE tanks, adjacent to the Hylebos Waterway) the highest concentrations were noted. Area 1 contained the lowest concentration zones. From these concentrations an estimate of the groundwater loading of chlorinated organics in pounds within each area was obtained (Table 1). Average groundwater outflow rates in gallons per day (gpd) for a 12-hour outflow period were calculated for Areas 2 and 3. These outflow rates were 1415 and 1573 gpd from Areas 2 and 3, respectively. These values when applied to the minimum, average and maximum organic concentrations in Areas 2 and 3 yield quantity outflow rates of total organics in lbs./day (Table 2). Based upon the average daily volume of water moving in and out of the Hylebos which is 8.89 billion lbs. (or dilution factor) the theoretical concentrations of total organics which can be expected in the Hylebos after dilution can be derived (Table 3). A minimum concentration in the waterway after dilution from the combined input of Areas 2 and 3 would be 0.67 ppb total organics and a maximum concentration of 1.42 ppb total organics based on groundwater outflow to the Hylebos and chemical loading of 6 and 12.6 lbs./day.

The report by Walker Wells, Inc. (December, 1980) provided a breakdown of the total organics into the 4 primary constituents (Dichloromethane, Chloroform, Trichloroethylene, Perchloroethylene) in order to obtain an approximation of their relative concentrations to be expected in the water of the Hylebos. As defined by Walker Wells, the percentage of each constituent present was obtained using the analysis of groundwater from Well 4-45, the most highly polluted well. The results are:

<u>Constituent</u>	<u>Predicted Concentration (in ppb)</u>		
	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>
Dichloromethane	0.007	0.010	0.014
Chloroform	0.460	0.700	0.980
Trichloroethylene	0.160	0.240	0.340
Perchloroethylene	0.040	0.060	0.085

Although the chemical load value of 12.6 lbs./day and the corresponding concentrations of the individual constituents may be considerably higher than those actually leaving the plant property, these are the maximum predicted values that will be used for comparison in the remainder of this discussion. This conservative approach in effect incorporates an additional safety factor.

Volatilization, a natural, physical, ongoing process will also greatly decrease the theoretical concentrations of all these organics in the Hylebos waterway. It is the major transport pathway for removal of these constituents from aquatic systems.

In order to put the concentrations of these constituents in proper perspective each will be discussed separately in light of known background levels in raw water and finished drinking water, and the recent water quality criteria.

Dichloromethane (Methylene Chloride)

In the National Organics Reconnaissance Survey (NORS) (USEPA, 1975), a nationwide survey of organics in drinking water, the U.S. EPA determined that dichloromethane was one of 18 compounds found most frequently in finished waters of 10 different cities surveyed. The sites surveyed represented 5 major categories of raw water sources (groundwater, uncontaminated upland water, raw water contaminated with agricultural runoff, raw water contaminated with municipal waste, raw water contaminated with industrial waste). Dichloromethane was detected in 9 out of 10 of these cities; Lawrence, Mass. had the highest concentration of 1.6 ppb.

The U.S. EPA conducted the National Organic Monitoring Survey (NOMS) (USEPA, 1977), to determine the frequency of occurrence of specific contaminants in finished drinking water supplies of over one hundred communities. Dichloromethane was found in 15 out of 109 samples. The lowest concentration found was 1 ppb in Davenport, Iowa and the highest concentration was 13 ppb in Boston, Mass.

EPA Region V (USEPA, 1975) performed a survey of eighty-three water utilities in that region. The study showed that 8% of the finished water supplies contained dichloromethane but only 1% of the raw water supplies did. The lowest concentration in finished water was 41 ppb with a maximum of 7 ppb. The lowest concentration in raw water was 41 ppb with a maximum concentration of 1 ppb.

Dichloromethane was also detected in municipal drinking water in two locations at a level of 45 ppb (Dowty et al., 1975; Saunders et al., 1975). In another location, dichloromethane was detected in drinking water at a level of 0.3 ppb (Fujii, 1977).

The following summarizes the dichloromethane levels:

<u>Studies</u>	Concentrations (ppb) = <i>ng/l</i>	
	<u>Minimum</u>	<u>Maximum</u>
From HCC Tacoma Plant after Dilution in the Hylebos	0.007	0.014
<u>Drinking Water Levels</u>		
NOR Survey (EPA) Finished Water	detected not quantified	1.6
Region V (EPA) Raw Water	41	1.0
Finished Water	41	7.0
NOM Survey (EPA) Finished Water	1	13.0

One important point to emphasize here is that dichloromethane is formed during chlorination water treatment. There is no U.S. EPA water quality criteria for dichloromethane.

Chloroform

In the National Organics Reconnaissance Survey (NORS) (USEPA, 1975) 80 water utilities were surveyed for both raw water and finished water analysis of chloroform. Out of 80 raw water samples, 49 had detectable

levels of chloroform from 40.1-0.90 ppb. In contrast all 80 samples of finished water surveyed contained chloroform in concentrations ranging from 40.1-311 ppb. The highest concentration of 311 ppb was in Miami.

In the National Organic Monitoring Survey (NOMS) (USEPA, 1977) chloroform was found to be ubiquitous in all three survey phases; in excess of 90% of all samples were positive for chloroform. Concentrations ranged from 1- >300 ppb. These high concentrations were prevalent in Melbourne and Tampa, Florida; Annandale, Virginia; Jackson, Mississippi and Santa Fe, New Mexico.

The EPA Region V (USEPA, 1975) survey showed that 95% of 83 finished water samples contained chloroform in the concentration range of 41-366 ppb. In contrast 27% of the raw water samples contained chloroform in the range of 41-94 ppb.

Chloroform is ubiquitous in rivers, lakes, groundwater, commercial effluent water and sewage treatment plant effluent water at nearly 100 U.S. and European locations (Shackelford & Keith, 1976).

There is no U.S. EPA water quality criteria for freshwater or salt-water aquatic life. However, information from the recent federal register indicates that acute toxicity to freshwater aquatic life occurs at concentrations as low as 28,900 ppb and would occur at lower concentrations among species that are more sensitive than those tested. Furthermore, chronic toxicity to freshwater aquatic organisms may occur as low as 1,240 ppb.

Historically application factors (e.g. 0.1, 0.05, 0.01) often called "safety factors" have been commonly used with toxicity data to estimate "safe concentrations" of toxicants in the aquatic environment for protection of aquatic life during chronic exposure. There are obviously several limitations to this approach. However, if we were to be unduly stringent and use 0.01 ($0.01 \times 28,900 \text{ ppb } [LC_{50}] = 289 \text{ ppb}$) the safe concentration of chloroform for acute exposure would be 289 ppb. Using the same application factor with the lowest concentration shown to produce chronic toxic-

ity ($0.01 \times 1,240 \text{ ppb} = 12.4 \text{ ppb}$) yields a safe concentration of 12.4 ppb for chronic exposure. These are calculated values for freshwater aquatic organisms, however, these concentrations are still much higher than those predicted concentrations for chloroform after dilution in the Hylebos waterway at the HCC Tacoma plant.

The following summarizes the chloroform levels:

<u>Studies</u>	<u>Concentrations (ppb)</u>	
	<u>Minimum</u>	<u>Maximum</u>
From HCC Tacoma Plant after Dilution in the Hylebos	0.46	0.98
<u>Drinking Water Levels</u>		
NOR Survey (EPA)		
Raw Water	<0.1	0.90
Finished Water	<0.1	311
Region V (EPA)		
Raw Water	<1.0	94
Finished Water	<1.0	366
NOM Survey (EPA)		
Finished Water	1.0	>300
<u>Water Quality Criteria</u> (Derived with Application Factor 0.01 Applied)		
Freshwater Acute Life		289
Freshwater Chronic Life		12.4

Chloroform concentrations in finished water are also produced as a result of chlorination water treatment.

Trichloroethylene (TCE)

In the National Organics Reconnaissance Survey (NORS) (USEPA, 1975) 5 cities in a 10 city survey indicated finished water supplies contained trichloroethylene at 0.1-0.5 ppb. The highest concentration was from Philadelphia, PA. Furthermore, between 3-25% of the finished water samples from phases I, II and III of the National Organic Monitoring Survey

(NOMS) (USEPA, 1977) contained trichloroethylene (1,1,2 isomer). Concentrations ranged from <0.06 -49 ppb at 38 locations. Des Moines, Iowa had the highest concentration.

Trichloroethylene has been detected in 88 out of 204 samples of surface waters near heavily industrialized areas, at levels >1 ppb (Ewing et al., 1977). TCE has also been found in tap, lake, spring and subterranean water, at levels of 105, 38, 5, 80 parts per trillion, respectively (Grob and Grob, 1974). It was also detected in a river at a level of 25 ppb (Rook et al., 1975).

The recent U.S. EPA water quality criteria do not specify any criteria for freshwater or saltwater aquatic life. However, according to this document the available data for TCE indicates that acute toxicity to freshwater aquatic life occurs at concentrations as low as 45,000 ppb and would occur at lower concentrations among species that are more sensitive. No data are available for chronic toxicity of TCE to freshwater organisms but it is stated that adverse behavioral effects to one species occurred as low as 21,900 ppb. In addition, the document indicates acute toxicity to saltwater aquatic life at concentrations as low as 2,000 ppb and would occur at lower concentrations if more sensitive species were used. No chronic toxicity data were available for saltwater organisms concerning TCE. If an application factor of 0.01 were used for TCE, safe concentrations for acute exposure ($0.01 \times 45,000 \text{ ppb} = 450 \text{ ppb}$) of freshwater organisms would be 450 ppb. In order to derive safe concentrations for chronic exposure of freshwater organisms the lowest behavioral effect concentration of 21,900 may be used ($0.01 \times 21,900 \text{ ppb} = 219 \text{ ppb}$) yielding a safe concentration of 219 ppb. For acute exposure of saltwater aquatic organisms the safe concentration is 20 ppb ($0.01 \times 2,000 \text{ ppb} = 20 \text{ ppb}$). These values far exceed the predicted concentrations after dilution of groundwater in the Hylebos.

The levels of TCE may be summarized as follows:

<u>Studies</u>	<u>Concentrations (ppb)</u>	
	<u>Minimum</u>	<u>Maximum</u>
From HCC Tacoma Plant after Dilution in the Hylebos	0.160	0.34
<u>Drinking Water Levels</u>		
NOR Survey (EPA) Finished Water	0.1	0.5
NOM Survey (EPA) Finished Water	<0.06	49
<u>Water Quality Criteria</u> <u>(Derived with Application Factor</u> <u>0.01 Applied)</u>		
Freshwater Acute Life		450
Freshwater Chronic Life		219
Saltwater Acute Life		20

TCE may also be formed during chlorination of water.

Perchloroethylene (PCE)

In the National Organics Reconnaissance Survey (NORS) (USEPA, 1975) 8 out of 10 cities surveyed contained PCE in finished water supplies in the range of <0.01-0.46 ppb. In the National Organic Monitoring Survey (NOMS) (USEPA, 1977) PCE was found in the range of 0.2-3.1 ppb at 10 locations. It has also been detected in drinking water at a number of localities at 0.5 ppb (Bertsch et al., 1975, Eurocop-Cost, 1976) and <5 ppb (Saunders et al., 1975).

Rainwater has also been found to contain up to 0.15 ppb PCE. Maximum concentrations in seawater were 2.6 ppb and maximum concentrations in sediments were 4.8 ppb.

According to the recent U.S. EPA water quality criteria document there is no criteria established for PCE for freshwater or saltwater aquatic life. However, as indicated in the document, the available data for PCE shows that acute and chronic toxicity to freshwater aquatic life

can occur at concentrations as low as 5,280 and 840 ppb, respectively, and would occur at lower concentrations among species that are more sensitive. Furthermore, the available data indicates that acute and chronic toxicity to saltwater aquatic life occurs at concentrations as low as 10,200 and 450 ppb, respectively, and would occur at lower concentrations among species that are more sensitive. Applying the application factor of 0.01 to the lowest acute ($0.01 \times 5,280 \text{ ppb} = 52.8 \text{ ppb}$) and chronic values ($0.01 \times 840 \text{ ppb} = 8.4 \text{ ppb}$) gives safe concentrations for freshwater aquatic life of 52.8 and 8.4 ppb, respectively. If this factor is then applied to the lowest acute ($0.01 \times 10,200 \text{ ppb} = 102 \text{ ppb}$) and chronic values ($0.01 \times 450 \text{ ppb} = 4.5 \text{ ppb}$) for saltwater organisms then 102 and 4.5 ppb are the safe concentrations.

The levels of PCE may be summarized as follows:

<u>Studies</u>	<u>Concentrations (ppb)</u>	
	<u>Minimum</u>	<u>Maximum</u>
From HCC Tacoma Plant after Dilution in the Hylebos	0.040	0.085
<u>Drinking Water Levels</u>		
NOR Survey (EPA)		
Finished Water	0.01	0.46
NQM Survey (EPA)		
Finished Water	0.2	3.1
Rainwater		0.15
Seawater		2.6
Sediments		4.8
<u>Water Quality Criteria</u>		
<u>(Derived with Application Factor</u>		
<u>0.01 Applied)</u>		
Freshwater Acute Life		52.8
Freshwater Chronic Life		8.4
Saltwater Acute Life		102
Saltwater Chronic Life		4.5

PCE may also be formed during chlorination water treatment.

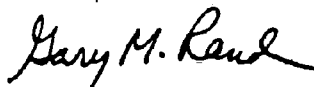
Summary

Predicted concentrations of dichloromethane, chloroform, trichloroethylene and perchloroethylene in the Hylebos after dilution are considerably less than normal background levels found in finished drinking water at numerous locations. Furthermore, concentrations of chloroform, trichloroethylene, and perchloroethylene are several orders of magnitude lower than the levels known to produce toxicity to aquatic organisms.

It should be noted that the predicted concentrations used for evaluation of each organic constituent were based on a "worst case" situation with a total chemical load of 12.6 lbs./day of total organics leaving the plant area and entering the Hylebos Waterway. The lack of sufficient toxicity data to calculate appropriate and applicable water quality criteria for aquatic life required the alternative application of "unduly stringent" safety factors to the lowest acute and chronic toxicity levels in order to derive "safe concentrations". The safe levels discussed are therefore extremely conservative.

Furthermore, although comparisons are made between levels of each chemical and the more limiting criteria applied to finished drinking water, it is not anticipated that this water will be used for this purpose.

In conclusion, based on the comparisons made, neither chloroform, trichloroethylene, or perchloroethylene pose a hazard to the aquatic ecosystem. Although insufficient aquatic toxicity data were reviewed for dichloromethane it also should not pose a hazard to aquatic life because its predicted concentrations in the Hylebos were several orders of magnitude lower than background levels in finished drinking water.



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